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From the Editors

It is our fervent hope that all our readers are safe and well and socially distancing. All members of *The Victorian Naturalist* team are observing the COVID-19 requirements of staying home and not gathering. However, we are also endeavouring, as far as possible, to maintain production of the journal through the period of the pandemic. This issue will not be the last you receive this year, but we cannot guarantee when the next one will be completed.

Of course, such production is possible only if we continue to receive manuscripts. If you have a paper that is almost finished, this period of enforced isolation could provide the time you need to complete it. You might have projects that need writing up; when you've done that, think of us. Our email system is being monitored on a regular basis so, while it may take a little longer than usual for us to respond, be assured that we are intent on continuing to publish and promote the study of natural history.

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The Victorian Naturalist

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Editors: Gary Presland, Maria Gibson, Sue Forster

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Research Report

Surveys for Leadbeater's Possum *Gymnobelideus leadbeateri* at Wallaby Creek, Kinglake National Park, *by Arabella C Eyre, Jemma Cripps, Vivianna Miritis, Darcy Watchorn, Kita Ashman, Phoebe Burns, Thomas Fairman, Louise Durkin, Jenny Nelson, Phoebe Macak, Lindy Lumsden and Dan Harley* 36

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Surveys for Leadbeater's Possum *Gymnobelideus leadbeateri* at Wallaby Creek, Kinglake National Park, Victoria

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Abstract
Extensive camera trapping surveys were conducted for Leadbeater's Possum *Gymnobelideus leadbeateri,* in Mountain Ash *Eucalyptus regnans* forest in the Wallaby Creek catchment, Kinglake National Park, Victoria, 22 km west of the species' known range. The habitat surveyed is dominated by dense stands of Mountain Ash regenerating from the Black Saturday bushfires in 2009. There is also extensive Silver Wattle *Acacia dealbata* regeneration and abundant mature, fire-killed eucalypts that provide a source of hollows. Across two survey rounds, 95 camera traps were deployed across 44 sites for survey periods of 6-9 weeks. Leadbeater's Possum was not detected at Wallaby Creek, and is considered to be absent from this locality. Seven other species of arboreal/scansorial mammal were detected during the camera trapping surveys. (*The Victorian Naturalist* **137** (2), 2020, 36–40)

Introduction

Leadbeater's Possum *Gymnobelideus leadbeateri* is a small (110-160 g) arboreal marsupial that is endemic to Victoria, occupying a 70 x 95 km region centred on the Victorian Central Highlands (Harley 2004; McBride *et al.* 2019). There were no confirmed reports of the species for over 50 years and it was presumed to be extinct, until its rediscovery in 1961 in the montane ash forests near Marysville, approximately 85 km north-east of Melbourne (Wilkinson 1961). The species is classified as Critically Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the IUCN Red List of Threatened Species (Woinarski and Burbidge 2016), and Threatened under Victoria's *Flora and Fauna Guarantee Act 1988*. Major threats include habitat loss from bushfires and timber harvesting, both of which act to limit the number of mature eucalypts possessing suitable hollows for denning, a habitat requirement for the species (Lindenmayer *et al.* 1997, 2013, 2018; Blair *et al.* 2018; Commonwealth of Australia 2016; Harley 2016).

Given Leadbeater's Possum's restricted distribution and the continued threat of large-scale disturbances (bushfire and timber harvesting) on the species remaining habitat, a detailed knowledge of the species' local distribution and abundance is critical for effective conservation planning. Previously, the cryptic behaviour of the species impacted our ability to reliably survey large areas in an efficient manner. However, this is now possible with baited camera traps (Harley *et al.* 2014). Since 2014, extensive camera trapping surveys have been conducted for the species resulting in a large number of new records, including some at the margins of the species' known range (McBride *et al.* 2019; Nelson *et al.* 2015, 2017). Surveys using this method also have been conducted at locations supporting potentially suitable habitat outside the known range in north-east Victoria (Eyre 2018).

The southern edge of the Hume Plateau represents the outlying western-most extremity of Mountain Ash *Eucalyptus regnans* in the Central Highlands (Ashton 2000a). These ash forests near Mt Disappointment contain some stands which are managed for timber production within State Forest, with the majority located in Wallaby Creek catchment in Kinglake National Park (hereafter referred to as 'Wallaby Creek'), which is reserved for nature conservation and water production (Dingle and

Rasmussen 1991) and has a long history of ecological research (Ashton 2000b). Prior to the 2009 bushfires, the ash forests of Wallaby Creek contained a mosaic of forest ages arising from various historical wildfires (Ashton 1976), with a central core of old growth forest estimated to have originated following a severe fire in 1730 (Ashton 2000b). However, the entire catchment was burnt at high severity in 2009 (Cruz *et al.* 2012), and the forests now comprise dense regenerating stands with large, fire-killed emergent eucalypts (Sillett *et al.* 2015).

Habitat suitability models developed for Leadbeater's Possum have identified Wallaby Creek as a location supporting potentially suitable habitat (Eyre 2018). Although the floristics at Wallaby Creek are similar to sites occupied by Leadbeater's Possum elsewhere in the Central Highlands (Ashton 2000b), there have been no records of the species there (e.g. Ambrose 1979; Macfarlane 1988). The nearest Leadbeater's Possum record is from 22 km to the east. A fragmented band of drier, mixed species forest, considered unsuitable for Leadbeater's Possum, separates the two areas.

During a thermal camera survey of Wallaby Creek in 2018, two of the authors (J Cripps and T Fairman) observed a small, unidentified arboreal mammal moving through dense regenerating forest in a manner typical of Leadbeater's Possum. This raised the possibility that there may be an undetected population beyond the western limit of the species' known range. This paper describes the results from two subsequent camera trapping surveys aimed at determining the presence/absence of Leadbeater's Possum at Wallaby Creek.

Methods

Study location

Wallaby Creek (-37.40663, 145.17683), part of Kinglake National Park, is situated 51 km north-east of Melbourne. Based on aerial imagery, the catchment supports more than 1200 ha of potentially suitable habitat for Leadbeater's Possum (A Eyre, unpub. data). Elevations range from 590 to 780 m asl. The area's mean temperature ranges from 16 °C in summer to 6 °C in winter (Fick and Hijmans 2017). The area receives greater than 1300 mm of rainfall annually (Fick and Hijmans 2017).

Camera trapping

Two rounds of camera trapping surveys were conducted to determine the presence/absence of Leadbeater's Possum at Wallaby Creek. The initial round from March–April 2019 (six weeks), undertaken by the Arthur Rylah Institute for Environmental Research (ARI), saw 21 camera traps deployed across seven sites (i.e. three cameras per site, Fig. 1). The second round from October–December 2019 (nine weeks), undertaken by Zoos Victoria, saw 74 camera traps deployed across 37 sites (i.e. two cameras per site, Fig. 1). Following camera retrieval, all images of mammals were identified to species level and the results collated for each camera trapping site.

The camera traps employed in these surveys were Reconyx motion-sensor cameras (models HC500, HC600, PC900, Ultrafire and Hyperfire 2) set to record five pictures per trigger, a RapidFire picture interval and no delay between triggers. Each camera trap was directed at a bait of creamed honey positioned 1–2.5 m away. The creamed honey was housed in a vent cowl. The camera traps and baits were installed on trees at heights of 3–7 m and cameras within the same site were installed 24–300 m apart.

Camera trapping was conducted at locations regenerating from the Black Saturday bushfires in 2009 that are similar to habitat at some sites occupied by the species elsewhere in the Central Highlands. Camera traps were installed at sites with the following notable habitat features: (i) a predominance of canopy and midstorey species used for foraging by highland Leadbeater's Possums, including Mountain Ash and Silver Wattle *Acacia dealbata;* (ii) large, emergent, fire-killed mature Mountain Ash, providing a source of hollows for denning, and (iii) dense vegetation structure that would facilitate possum movement through the midstorey.

Results

The 95 camera traps (across 44 sites) recorded a total of 177 603 images. Seven species of arboreal and scansorial mammal were detected, including the Common Ringtail Possum *Pseudocheirus peregrinus*, Mountain Brushtail Possum *Trichosurus cunninghami*, Sugar Glider *Petaurus breviceps*, Feathertail Glider *Acrobates* sp., Eastern Pygmy Possum *Cercartetus nanus*,

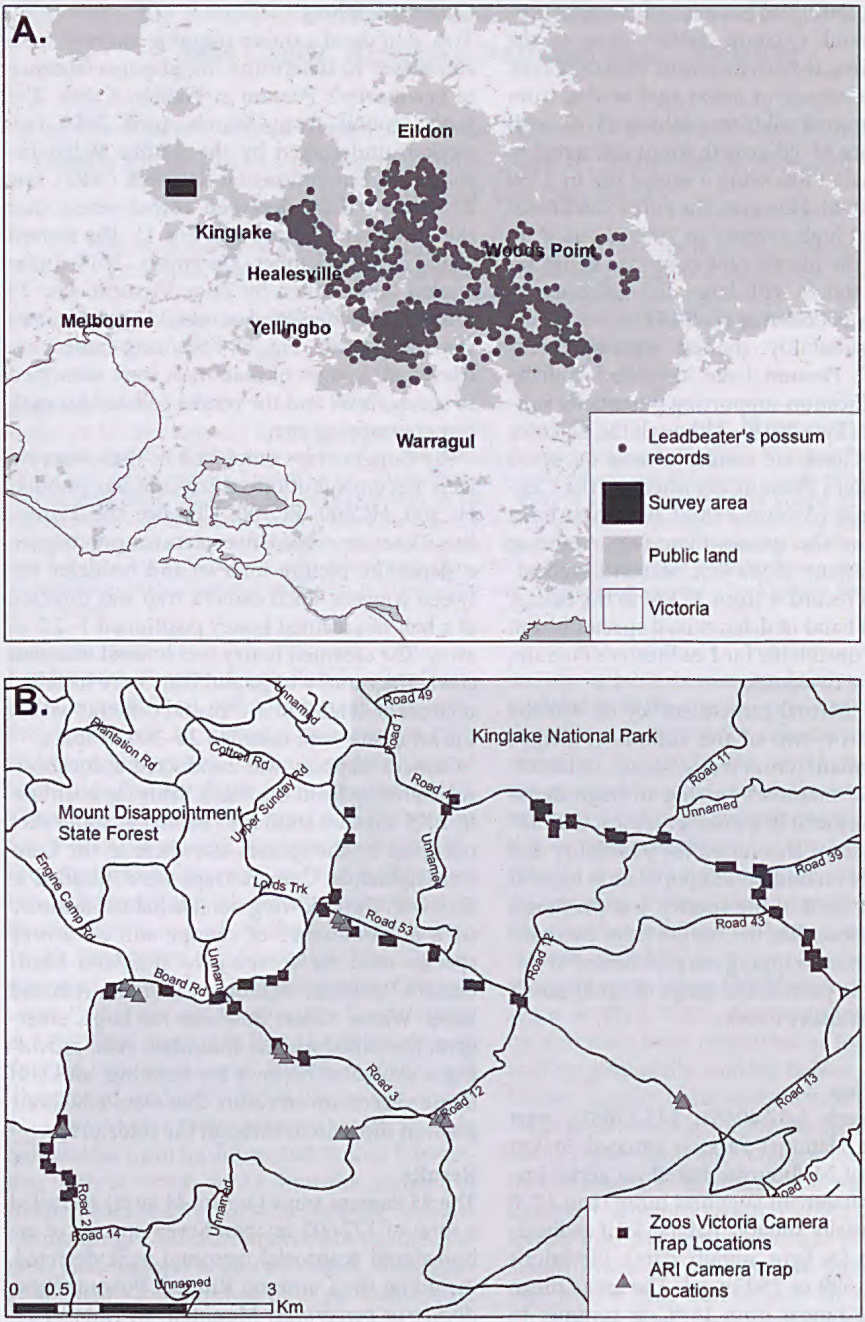

Fig. 1. A) Location of the survey area at Wallaby Creek, Kinglake National Park, relative to Leadbeater's Possum's known range. B) Camera trapping locations for Leadbeater's Possum at Wallaby Creek across the two survey rounds during 2019.

Agile Antechinus *Antechinus agilis* and Bush Rat *Rattus fuscipes* (Table 1). There were no detections of Leadbeater's Possum. The most commonly detected mammal was the Common Ringtail Possum, being recorded at 39 of 44 camera trapping sites (89%). The Sugar Glider, a species of similar size and diet to Leadbeater's Possum, was detected at nine of the 44 survey sites (20%).

There was broad similarity in the survey results obtained during the two rounds of camera trapping. Six arboreal/scansorial mammals were detected in the first survey period and one additional species, the Eastern Pygmy Possum, was detected at six of the 37 survey sites (16%) during the second survey period. The Zoos Victoria surveys detected seven species of arboreal/scansorial mammal and the ARI surveys detected six species (Table 1). The Common Ringtail Possum and Agile Antechinus were the most frequently detected during both survey rounds. However, the first round, conducted by ARI, detected Mountain Brushtail Possums and Bush Rats at a far greater percentage of sites compared to the later surveys conducted by Zoos Victoria.

Discussion

Given high detection probabilities for camera trapping surveys targeting Leadbeater's Possum within the species' core range in the Victorian Central Highlands (Nelson *et al.* 2017), coupled with the large number of camera traps deployed at Wallaby Creek, we can conclude with confidence that this locality does not currently support a Leadbeater's Possum population. While the presence of the species there prior to the Black Saturday bushfires, and subsequent local extinction, cannot be discounted, this is considered unlikely given that seven other arboreal and scansorial mammal species, also impacted by the 2009 bushfires, were detected at the site during these surveys. A more likely explanation is that the outlying Mountain Ash forest at Wallaby Creek was never colonised by Leadbeater's Possum, owing to the band of dry forest being a dispersal barrier from suitable, occupied habitat 22 km to the east.

The spatial extent of the surveys reported here was restricted to the Wallaby Creek catchment within Kinglake National Park, and did not extend to adjoining areas of Mountain Ash forest in Mt Disappointment State Forest. However, the large spatial extent surveyed, coupled with the detection of all small to medium-sized arboreal/scansorial mammals associated with Mountain Ash forest elsewhere in the Victorian Central Highlands, with the exception of Leadbeater's Possum, indicate that the results provide a reliable representation of the arboreal mammal fauna in the general area. Some species detected here (e.g. Agile Antechinus and Common Ringtail Possum) had not been recorded in surveys by Ambrose (1979). Macfarlane (1988) suggested the site was unsuitable for small non-gliding arboreal species, such as Leadbeater's Possum and Common Ringtail Possum, as it lacked well developed midstorey vegetation to facilitate the movement of such species. This has since changed following the 2009 bushfires, with high stem densities of *A. dealbata* in the post-fire regeneration. The number of species present 10 years following high severity bushfire is notable. However, it is uncertain whether various species persisted there post-fire or have subsequently

Table 1. Species detected using arboreal camera traps at Wallaby Creek, Kinglake National Park. The Zoos Victoria results are based on 37 sites (74 camera traps). The Arthur Rylah Institute for Environmental Research (ARI) results are based upon seven sites (21 camera traps). Species are listed in order of detection prevalence.

Species	Sites detected Zoos Vic surveys	Sites detected ARI surveys
Common Ringtail Possum *Pseudocheirus peregrinus*	32 (86%)	7 (100%)
Agile Antechinus *Antechinus agilis*	26 (70%)	7 (100%)
Mountain Brushtail Possum *Trichosurus cunninghami*	16 (43%)	6 (86%)
Feathertail Glider *Acrobates* sp.	9 (24%)	1 (14%)
Sugar Glider *Petaurus breviceps*	7 (19%)	2 (29%)
Bush Rat *Rattus fuscipes*	4 (11%)	5 (71%)
Eastern Pygmy Possum *Cercartetus nanus*	6 (16%)	0 (0%)

recolonised from unburnt refugia in neighbouring areas. Given the absence of pre-fire data, it is also uncertain how the extent of occupancy and/or abundance of different species may have changed due to fire impacts.

The current condition of regenerating forest at Wallaby Creek meets all of the key ecological requirements of Leadbeater's Possum: hollow-bearing trees for denning, appropriate eucalypt and midstorey species to provide food resources, dense vegetation structure to facilitate movement, and a cold, wet climate (Harley 2004). One objective of the Draft National Recovery Plan for Leadbeater's Possum is to seek to locate, or establish, additional populations outside the core range of the Central Highlands (Commonwealth of Australia 2016). Given the possum's restricted range, this is an important risk-spreading approach to contend with the threat of major bushfires. The apparent absence of the species from Wallaby Creek, and the large area of suitable habitat (>1200 ha), make it a suitable candidate site for population establishment through translocation in order to meet strategic conservation and recovery objectives for the species.

Acknowledgements

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Pollination by sexual deception of different fungus-gnat species, two (Mycetophilidae) in *Pterostylis grandiflora* and two (Sciaridae) in *P. nana* (Orchidaceae)

Introduction

It has been noted that populations of *Pterostylis grandiflora* in East Gippsland and southern Victoria were pollinated by different fungus-gnats in the genus *Mycetophila*, but the populations were allopatric so it was thought that the orchids were, possibly, sub-specific (Kuiter 2016). A 2019 study of a single population of *P. nana* in the Langwarrin Flora and Fauna Reserve comprised about 60 plants, with most flowering over a period of two to three weeks. Here, the pollinator, a sciarid, was found to be a different species from the vector observed on *P. nana* at McLoughlins Beach in East Gippsland (pers. obs., Kuiter, 15 July 2016). In this case, there was no doubt that the orchids were the same species.

As with most members of *Pterostylis*, the vector attraction of *P. grandiflora* and *P. nana* is by sexual deception. Their kairomones are presumed to be emitted by their long lateral sepals, as on both species the male vectors show a strong attraction to these prior to landing on the hood and entering the flower. Many individuals of both vector species were observed over various seasons at several different localities, confirming consistent identity of the fungus-gnats at each site. *Pterostylis* comprises a large number of species forming tribes, complexes, or clades that are species-selective in their vector attraction. Many *Pterostylis* species are restricted to a single vector species, but within the *Pterostylis* clades, a number of different species share the same vector species, whilst in other clades they may share members of a particular vector genus. Based on observations of fungus-gnat wing-venations, all members of the rustyhood-clade attract species of fungus-gnat from the genus *Orfelia* of the large Mycetophilidae assembly, subfamily Keroplatinae: clade Orfeliini, (Kuiter and Findlater-Smith 2017). *Mycomya* sp. 2 (Kuiter 2016), also a member of Mycetophilidae, is a vector shared in Victoria by five *Pterostylis* species: *P. acuminata, P. cucullata, P. falcata, P. nutans*, and *P. oreophila* in single vector relationships.

It is clear that *Mycomya* sp. 2 is geographically widespread and occurs in a great variety of habitats from low coastal to very high altitudes, but very little is known about the distribution of any of the Sciaroidea species in Victoria. While many genera are widespread globally, many species may be limited in their geographical distributions or a taxon may even have a unique habitat. Historically, allopatric species of the orchids and their vectors may have become sympatric because of habitat alterations.

Pterostylis grandiflora (north-eastern)

Populations of *P. grandiflora* in close vicinity to Melbourne were checked for pollinating vectors for many years, but none were seen and no evidence of pollination was found. It was in East Gippsland, near Stockdale in 2014, that numerous seed-pods were first noticed. From 20–22 June, several visits were made to the site and, on different days, vectors were seen flying in large numbers. Only males were seen homing-in on the flowers and typically landed first on the long tips of the lateral sepals that emit the kairomones. They were witnessed collecting and depositing pollinia. On 21 June it was cold, probably below 10 °C and cloudy, but good numbers were seen engaging with the flowers. On the next day the weather was much warmer, about 16 °C and sunny, and then the number of males seen on flowers was phenomenal and at times two were entering one flower simultaneously. They were most commonly seen flying near the bottom of a large mossy gully lit by the sun, where this greenhood was scattered on the slope amongst shrubs in more open areas. Vectors were easily recognised by their unusual erratic flying and, at times, many individuals were seen flying around the orchids and nearby in the general area. When the vectors entered the large flowers, labella were only occasionally triggered and very few individuals were seen flying out with pollinia attached to the thorax, leaving without a photo opportunity. With many pollinators being active, it

seemed the trigger sensitivity of labella was reduced after resetting many times, and most of the pollinaria were already taken, but individuals were photographed flying in with pollinia on the thorax. A flower was checked and the pollinia were gone from the anther, but some pollen was deposited on the stigma.

The fungus-gnat vector was a surprisingly small species in relation to the flower size (Figs. 1 and 2), but its escape route through the column wings is also small, as the flower's architecture has evolved to match this taxon. The flower measured 25 mm in height, which made the calculated length of the insect in the images about 3 mm. Its tiny size and sensitivity to the camera makes it difficult to get detailed close-ups. Based on its wing-venation, this fungus-gnat species is a member of the family Mycetophilidae, genus *Mycetophila*. The taxon is distinguished by its bulbous brown thorax, dusky grey abdomen and spiky leg sections (Fig. 3).

With the fungus-gnat vector being so rare in most other places, it would be of interest to determine whether it is normally common at this site, but this would require monitoring over many seasons. Based on seasonal observations of other vector species, it seems that fungus-gnats are occasionally seasonally abundant. In areas where pollination is poor at sites, the pollinators may have become very rare or have vanished at such sites, probably because of habitat alterations.

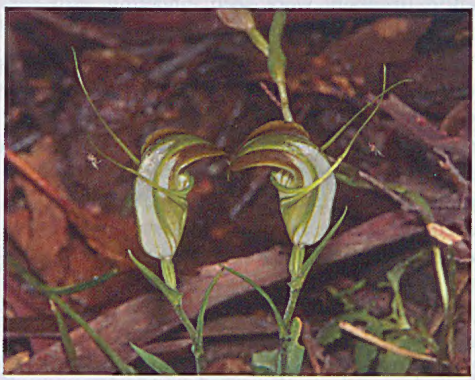

Fig. 1. *Pterostylis grandiflora* in East Gippsland with two *Mycetophila* sp. 3 pollinators. Compared to the flower, they are tiny, but of the correct size to function as a vector in the architecture of the column.

***Pterostylis grandiflora* (south-eastern)**

This orchid is locally common in the Gurdies, the forested hills from Belgrave to Hedley, and in Mullungdung, but very few seed pods were found in these areas over about five seasons from 2010 to 2014. At the time it was thought that these may have been caused by self-pollination. Pollinators were looked for over many seasons, but none were seen during visits until 2015, when finally vectors were observed on sunny warmish days with temperatures reaching 13 °C and 16 °C. Very few appeared on each day and all observations were between 11:00 am and 2:00 pm. On every visit, more time was spent searching, but no others were seen. The male vectors were observed typically homing in on the lateral sepals and several times seen entering a flower, and one was trapped for a considerable time. Compared to the *Mycetophila* vector species from north-eastern sites, which has a pale brown thorax and legs with spiny sections (Figs. 2 and 3), the south-eastern vector *Mycetophila* sp. from south and west of the Latrobe Valley, is clearly a different taxon, distinguished by its black thorax and its lack of series of small leg spines. This black taxon (Figs.

Fig. 2. *Mycetophila* sp. 3 with a pollinarium.

4 and 5) is referred to as sp. 8 (Kuiter 2016). The differences are diagnostic; these dipteran taxa are not simply just geographical variations. The identification of the genus is based solely on the wing-venation. Whether the involved vector species are congeneric is uncertain. As there were no experts on Australian Sciaroidea available to assist in identifications, no attempts were made to collect specimens.

As two *Mycetophila* spp. are attracted to the same *Pterostylis* species, the question remains as to whether their pheromones and kairomones differ. No baiting experiments were conducted due to orchid protection laws.

Pterostylis nana

Different pollinator species also have been noted for the Dwarf Greenhood *Pterostylis nana*, which is locally common in Victoria, and vectors have been observed in small numbers in various parts of the state. However, this orchid is rare at the main study site in the Langwarrin Flora and Fauna Reserve and at present is known only from a single population (Fig. 6). In 2017 a few vectors were seen engaging with flowers in this population and eight seed-pods were produced. To observe pollinators, it is best to work with fresh flowers. Daily visits were made after the first flowers opened on 19 July 2019. No vectors were seen until about 12 flowers were fully open and on the first day three individuals were observed interacting with the flowers. They clearly homed in on the lateral sepals and their actions included entering flowers, but pollinaria were not seen to be taken. The following day many more flowers had opened and four individuals were seen engaging with flowers and some emerged with the pollinaria, mostly with a single pollinium, but one carried two pollinia (Fig. 7a and 7b). For several days after, as more flowers opened, many individuals were observed each day and over 100 images were taken, recording every detail. These fungus-gnats move around rapidly like small ants. Based on their wing-venation, they appear to belong to the Sciaridae family, suggesting the genus *Trichosia* (*Sciara*) (Fig. 8), but wings are similar in some other genera. Only males are attracted to the flowers and typically land on the upright lateral sepals first and may spend much time on these before going onto the hood or into the flower. This species is tiny; two individuals measured 1.7 and 2.3 mm in length. They are mostly dark grey and black, and their antennae are relatively long, subequal to the length of their abdomen. Wings

Fig. 3. *Mycetophila* sp. 3 has a brown thorax, a shiny black abdomen and its legs have a series of small spines. It has been observed only in East Gippsland.

Fig. 4. *Mycetophila* sp. 8 has a black thorax, a dull black abdomen and its legs are smooth, lacking the series of small spines. It is known from Belgrave, Mullungdung and the Gurdies.

Fig. 5. *Mycetophila* sp. 8 on *Pterostylis grandiflora*: at Baluk Willam, (right) and at the Gurdies (left).

Fig. 6. *Pterostylis nana* colony in the Langwarrin Flora and Fauna Reserve, comprising about 60 plants, most with fully open flowers, whilst a few are still with small buds. Flowering time is over several weeks. This is the main study site for observing pollinators on this tiny greenhood.

are dusky transparent with bluish-pink reflections (Figs. 7a, 7b, 8, 9, 11). Vectors that were seen on *P. nana* at Chiltern (8 July 2014) and Inglewood (5 September 2015) looked identical, but may represent different taxa. Vectors on *P. nana* at McLoughlins beach, East Gippsland (15 July 2016), were of similar size, but looked markedly different due to their brown thorax and also their antennae being proportionally shorter (Fig. 10). Presumably, they were of a different taxon.

Fig. 7a. *Pterostylis nana* with vector showing a pollinarium on the vector's thorax.

It is impossible to determine or estimate the number of taxa in the family Sciaridae due to their minute size, their cryptic nature, and lack of research on them. Historically, few people have specialised in the taxonomy of the Sciaroidea in Victoria or Australia. However, 20 genera are recognised (Australian Faunal Directory). The importance of the environmental roles fungus-gnats play is greatly underestimated. That many are specific pollinators of many of the Victorian terrestrial orchids is largely unknown, as this has only recently come to light. In general, fungus-gnats are treated as pests and research largely evolves around eradicating them.

Pollinator attraction by sexual deception

Finding more than one vector species attracted by sexual deception to the same greenhood orchid was unexpected. Studies have been

Fig. 7b. *Pterostylis nana* with vector on the flower just to the left of centre. The flowers are small (15 mm in height), but its vector is tiny (2.3 mm long).

Fig. 8. *Sciaridae* sp. 1. Showing a clear image of the wing-venation and long antennae.

Fig. 9. *Sciaridae* sp. 1 is mostly black and has long antennae, subequal to length of its abdomen.

conducted on most Victorian *Pterostylis* spp. and it was found that the expected 1:1 relationships were limited to certain species. Sibling orchid taxa may share the exact same vector insect and some clades share members of a

Fig. 10. *Sciaridae* sp. 2 has a brown thorax and its antennae are shorter than its abdomen.

single vector genus (Kuiter and Findlater-Smith 2017). A complete study of all orchid pollinators of Victoria (Kuiter 2016) has shown that with sexual deception the orchid to vector species ratios can be highly variable.

All five members of the orchid genus *Cryptostylis* attract the same ichneumonid wasp *Lissopimpla excelsa*. On the other hand, *Caleana major* attracts males of multiple Pterygophorides: genus *Lophyrotoma*, with four species known to date (Kuiter 2017). *Paracaleana minor* attracts different thynniid male members of the genus *Neozeleboria*. The well-studied *Caladenia* spider-orchid members are usually claimed to have strictly 1:1 relationships with male thynniid wasps, and the taxonomy of these orchids is influenced by this. In the *C. brachyscapa/australis* group plants look identical, but are assigned to various taxa by the different thynniid wasps they attract. Due to flightless females, thynniid wasps' taxa are highly localised. Orchids such as *Chiloglottis* attract male *Neozeleboria*, but what species they attract appears to depend on locality. Taxonomy based on

different vectors is questionable and needs to be verified and backed-up by conventional methods. Differences in the pheromones between sibling species are important when sympatric to avoid hybridisation and to retain their identity, but, when allopatric, the sex-pheromones of different species are possibly identical, as they don't play a distinguishing role. Thus, species geographically well apart may have the same pheromones, but when sibling species are attracted to the same orchid, it suggests the orchid has broad spectrum kairomones that encompass marginal differences in the pheromones of local taxa. With some of the other orchids, different vectors can be sympatric, but with sibling species the pheromones are probably only marginally unique.

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Figs. 11a, 11b. *Sciaridae* sp. 1. This vector was considerably smaller, measuring only 1.7 mm long, which makes the attached pollinia seem very large. The way they are attached suggests they come from two different flowers, but neither pollinia shows signs of erosion. This vector was found during the second week of observations of the *Pterostylis nana* colony in the Langwarrin Flora and Fauna Reserve.

Little and Long-billed Corellas feeding on seeds from cypress cones at Notting Hill, Victoria

From 31 December 2018 until mid February 2019, a small flock of about 10 Little Corellas *Cacatua sanguinea* spent many hours eating seeds from the cones on two cypress pines that grow on either side of the entrance to our driveway. During the first week they arrived each morning, then departed for a while and returned in the afternoon; subsequently, they came mainly in the morning.

To human eyes, their method of feeding appeared very untidy and wasteful: during each feeding session they dropped a huge number of leaves, cones and seeds onto the footpath and driveway. Altogether my husband (Jurrie) and I swept up four large barrow-loads of cones and leaves to compost. The Little Corellas that I was able to observe were using the left foot to hold the cones, as in Fig. 1. In a study concerning lateralised foot use in parrots, Brown and Magat (2011) found that 90.5% of Little Corellas are 'left-footed'.

Having had easy meals 'prepared' for them, a flock of about 40 Long-billed Corellas *Cacatua tenuirostris* flew in to feed on the thousands of fallen seeds. They made several visits, but not when Little Corellas were present. Even after they stopped coming, a very large number of seeds remained. Perhaps the birds wanted a change, or a preferred food had become available.

According to Menkhorst *et al.* (2017), Pizzey and Knight (1997) and Frith (1976), both Little and Long-billed Corellas feed on the ground. Simpson *et al.* (1999, p. 132) state that Long-billed Corellas feed on the ground, and the illustration on p. 133 shows both species feeding on the ground—grass seeds, grain, bulbs and corms make up much of their diet. However, Wikipedia website mentions that Little Corellas occasionally feed in trees and shrubs. Although I was not surprised to see these birds feeding in the cypresses, which were a source of readily available food, I did expect them to eat some of the seeds that they dropped on the ground. As far as I could tell, only the Long-billed Corellas took advantage of that bounty.

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Wikipedia web site <https://en.wikipedia.org/wiki/Little corella> (Accessed 14 January 2020).

Fig. 1. Little Corella *Cacatua sanguinea* holding a cypress cone with its left foot.

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Storm damage at Cape Paterson: marine invertebrates found dead on the beach

On the morning following a storm, an array of freshly dead crabs and molluscs lay scattered on the sand and rock platform immediately south-west of the boat ramp at Cape Paterson Bay beach, Bunurong Marine Park, south of Wonthaggi, Victoria.

Soon after 9 am on 10 May 2019, an exceptionally severe and prolonged thunderstorm coincided with low tide at Cape Paterson. The Bureau of Meteorology radar site showed a black cell, the highest category of rainfall, situated above Cape Paterson during the storm. The township, foreshore reserve, beach and rock platforms were blanketed with a thick layer of small hail. Photographs of what appeared to be snow were circulated in the media (farmweatheronline website 2019). There is no official reading of the rainfall that fell during the storm as there were no official gauges within the area. Estimates vary from 50 to 200 mm. On the eastern side of the boat ramp, water dammed in the grassed depression behind the primary dune and eventually broke through, undermining the Wonthaggi Lifesaving Club building and gouging a huge gutter as it gushed towards the sea (*The Great Southern Star*, 14 May 2019). Almost one kilometre to the west of the Bay Beach (Area 27), at First Surf Beach (Area 26), where the cliffs are higher, a small creek which runs down the cliff face became an impressive 'waterfall', projecting water onto the beach far beyond the cliff base (Wendy Savage, pers. comm., June 2019).

The following morning, a selection of invertebrate casualties was gathered (Fig. 1). They were all found within about a metre of each other, so thickly were they scattered, but the whole area where they were found extended only about 20 or 30 m along the Bay Beach. It was estimated that well over 100 crabs and almost as many of the other species lay dead on the beach (Wendy Savage, pers. comm., June 2019). Fig. 1 shows: five Red Rock Crabs *Plagusia chabrus*, one Swift-footed Shore Crab

Fig. 1. A few of the dead marine invertebrates, and two of the mud balls found on the beach near the boat ramp at Cape Paterson the day after the storm. Photo Wendy Savage.

Fig. 2. Purple-mottled Shore Crab *Cyclograpsus granulosus*. Photo Wendy Savage.

Fig. 4. Chiton *Ischnochiton australis*. Photo Wendy Savage.

Fig. 3. There were many Red Rock Crabs *Plagusia chabrus* among the casualties. Photo Wendy Savage.

Fig. 5. Elephant Snail *Scutus antipodes*. Photo Wendy Savage.

Leptograpsus variegatus, two Chitons *Ischnochiton australis*, two Elephant Snails *Scutus antipodes* and two balls of clay containing a number of pebbles, shells and smaller molluscs. A third species of crab, a Purple-mottled Shore Crab *Cyclograpsus granulosus*, is shown in Fig. 2 (source used for species names: ABRS: <https://biodiversity.org.au/afd/taxa>). Figs. 3, 4 and 5 are close-ups of the casualities; in numerical order: Red Rock Crab, Chiton and Elephant Snail.

These species are among the largest invertebrates that inhabit the rock platforms at Cape Paterson. All of them usually shelter under rocks, in rock pools, in crevices or under ledges. What aspect or aspects of the storm led to their deaths? A heavy layer of hail would have covered the exposed rock surfaces, floated and slowly melted in the rock pools and the surrounding shallow waters. As the tide rose, mixing of the water would lower the temperature and dilute the sea water. A huge volume of fresh water was delivered onto the beach and rock platform during the storm and as rain continued during the day. Water drained from the higher ground of the Cape Paterson Foreshore Reserve where hard surfaces in the caravan

parks, car parks, roads and tracks would have acted as an effective catchment. The volume of water was probably augmented by storm water from parts of the adjoining township.

The creatures that were found dead, inhabitants of the intertidal zone, must be adapted to survive a wide range of temperature and salinity levels and strong wave action. We don't have any way of knowing which factor or, more likely, combination of factors, killed the animals. Those of us who are familiar with intertidal invertebrates along the coast of South Gippsland are aware that they are able to survive extremely low water temperatures and doubt that low temperature alone would be a main cause of the deaths. The dilution of sea water by such an extreme volume of fresh water would have placed the animals under stress. There might have been a tendency for water to enter the tissues of the animals by osmosis, possibly resulting in the bursting of cells. There were no reports of exceptionally rough seas in the bay that day and no evidence of physical damage was observed on the dead animals. However, the creatures, especially if already weakened, might have been dislodged and washed from their relatively sheltered positions by wave action.

Rock platforms in the area are extensive and known to support rich and diverse communities of marine life. The question of exactly what caused the unfortunate deaths of so many marine creatures and why they were only on this particular section of the beach remains unresolved.

Acknowledgements

The author wishes to thank Wendy Savage, who observed and photographed the dead creatures and later drew my attention to this event. Wendy also provided information about the situation on the day of the storm.

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Ninety-one Years Ago

THE BRUSH-TAILED PHASCOGALE

By DAVID FLEAY

More numerous in the days before the scourge that took heavy toll of so many of the Dasyuridae, the Brush-tailed Phascogale is not a common animal; but when present—especially in the vicinity of a farm—his work is sometimes seen in the shape of a dead fowl. One of my bush friends tells of frequent visits, in bygone years, from a Tuan; and, as he says, the "hurry-up" given to sleeping starlings in the roof was a thing to be remembered.

Recently a dead specimen was forwarded to me. It was killed in a rabbit trap, and, apparently, after the mother's death, a number of young ones had been born. Probably finding their way along the hair tracts, the tiny creatures reached the pouch area, but never became attached to the teats. Dissection showed unborn embryos.

From *The Victorian Naturalist* **XLVI**, p. 134. October 10, 1929

A brush with death: roads and Brush-tailed Phascogales

Introduction

Roads can have an adverse influence on wildlife by reducing habitat connectivity and causing roadkill (Fahrig and Rytwinski 2009, Strasburg 2006, Taylor and Goldingay 2010, van der Ree *et al.* 2015). Such effects can exacerbate other impacts on threatened species. The Brush-tailed Phascogale *Phascogale tapoatafa* (Fig. 1) is a threatened arboreal mammal that occurs in low densities throughout much of its former range in eastern Australia. Despite being a frequent roadkill victim, no studies have investigated whether road mortality poses a threat to the long-term survival of the species. I initiated a pilot investigation to determine whether males and females were equally vulnerable to being killed on roads and whether this varied with time of year.

Observations

In this investigation, Phascogale roadkills in Central Victoria were recorded opportunistically during 2018 and 2019. Additional roadkill records, including some from other years dating back to 2011, were retrieved from the Victorian Biodiversity Atlas and by word of mouth.

Records were obtained of 52 Phascogales killed on roads by vehicles. The majority (60%) were males, although gender was not established for 27% of kills (Fig. 2). Most discoveries of Phascogale roadkill were on rural roads with very low traffic volumes. Roadkill observations occurred throughout the year but peaked in June (Fig. 3).

Discussion

The roadkill numbers were surprisingly high given the secretive behaviour of Phascogales, as these animals spend a large amount of time in trees. Deaths occurred throughout the year but peaked during the breeding months when males search for mates. After the mating period, male Phascogales die as a result of stress-induced disorders (Schmidt *et al.* 2006), which would explain the sudden decrease in deaths in August. All females killed were found early in the breeding season (June to August), when young were likely to be present in the pouch.

Phascogales have been shown to use roadsides frequently in agricultural landscapes due to the high density of hollow-bearing trees

Fig. 1. Brush-tailed Phascogale, Black Hill Reserve, Kyneton, Victoria.

used for nesting (van der Ree *et al.* 2001). It is not known whether preference for high quality roadside habitat leads to higher numbers of Phascogale roadkills or if this is the result of another attractant such as carrion. Scarff *et al.* (1998), having detected remains of a Brush-tailed Possum in a Phascogale scat, suggested Phascogales may scavenge on carrion. Recently, camera trapping (Fig. 4) has recorded a Phascogale consuming a dead bird, lending support to the idea that the species could be attracted to roadkill. Phascogales also may be attracted onto roads for other reasons and, like quolls (Hobday and Minstrell 2008), may have a slow response to approaching vehicles, making them an easy target or inevitable road victim. On one occasion, a Phascogale was observed feeding on invertebrates in the middle of the road (Terry and Johnson 2018). This particular individual continued feeding and appeared fearless of approaching vehicles. Several cars passed before it finally decided to move off the road.

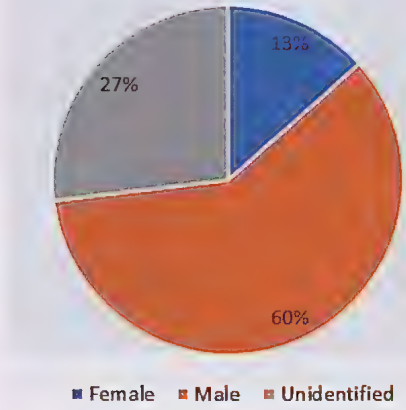

Fig. 2. Percentage of roadkill based on sex. Some animals could not be sexed due to the amount of damage present.

This pilot investigation raises several questions about why Phascogales are being killed on roads. Other arboreal native mammals that occupy similar habitats to Phascogales, such as Sugar Glider *Petaurus breviceps* and Agile Antechinus *Antechinus agilis,* were not recorded as roadkill during the same period (Victorian Biodiversity Atlas, accessed 23 February 2020). While there may be some potential solutions to prevent Phascogale deaths (Terry *et al.*

Fig. 3. Phascogale roadkills from 2011 and the months recorded. This chart includes observations from the Victorian Biodiversity Atlas and from word of mouth accounts. Note that the male die-off of Phascogales naturally occurs in June.

Fig. 4. Brush-tailed Phascogale consuming a dead rosella in a garden in Lauriston, Victoria. The bird had died of natural causes.

2018, Smith *et al.* 2015), their success may be limited without a greater understanding of how and why Phascogales interact with roads.

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Odd place for an ootheca, and a failed experiment

On the afternoon of 3 April 2019, I was unpegging my washing when I felt a lump on one of the items of clothing: a female praying mantis had placed its ootheca (egg case) very firmly on a pair of my husband's underpants! Unfortunately, I accidentally cracked an end of the egg case as I removed the underpants from the clothesline.

Using a razorblade, I removed the remainder of the egg case without causing further damage, glued it to the south-facing brick wall of our house using a Bostix BluStik™, and hoped that at least some of the remaining eggs might survive. I had no idea that I was putting the ootheca in potential danger.

From time to time I checked to see if it was still there. On 14 June I took a closer look. The ootheca appeared to be in good condition, but a spider had placed its web over it, so if the occupants hatched they might become meals for the spider. The positioning of the web may have been coincidental; if not, it could indicate some forethought on the part of the spider.

By the end of November some pieces of the ootheca were flaking off, and there was no sign that any young mantises had exited. I cut the ootheca open and found that the white eggs inside had completely dried up, so my experiment was unsuccessful.

Praying mantises normally place their oothecae on solid surfaces, such as house walls and eaves, fences and plant stems. I also have seen them on canvas awnings close to vegetation. However, clothing flapping about in the breeze on a washing line seems to be a most unusual choice of location.

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Fig. 1. Damaged ootheca glued to brick wall, with spider web over it.

Mistletoes of Southern Australia. Second edition

by David M Watson with illustrations by Robyn Hulley

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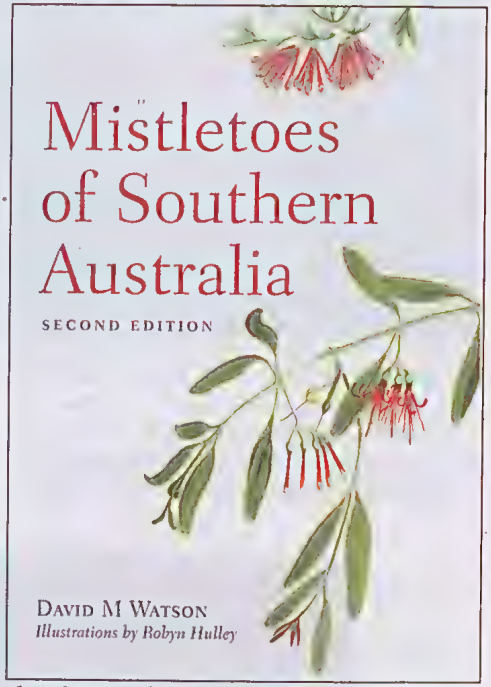

I remember a student bringing me a small branch of a plant and asking whether I could identify it. When I said it was a mistletoe I was promptly told by the student, 'no, it's a eucalypt'. Even after explaining what a mistletoe was and showing published photographs of the species presented, including its attachment to its host (haustorium), the student remained adamant the specimen was part of the eucalypt on her parents' property and that a haustorium was not present. I suggested she have another look when next visiting her parents. The following week, she returned and excitedly stated I was correct. She was thrilled to have 'discovered' such a unique plant.

Mistletoes also have fascinated me for many years, and I have photographed them throughout my travels. I was glad, therefore, that a second edition of *Mistletoes of Southern Australia* had been published. The text has been updated throughout, there are new distribution maps and a number of photographs have been replaced with better examples. The photographs and illustrations are excellent and complement the easily read text.

The book is divided into six chapters: 1. Biology; 2. Identification; 3. Species accounts—Loranthaceae and Viscaceae; 4. Ecology; 5. Cultural significance; and 6. Restoration and management. A species list, references and an index are provided. A number of sidebars (separate companion pieces) also are included throughout the book; e.g. Derivation of the word 'mistletoe' (p. 3); Mistletoe on mistletoe, (p. 128); The Painted Honeyeater: Australia's original mistletoe bird (p. 135); Mistletoe and Christmas: the druid connection (p. 154).

In Chapter 1 we learn what a mistletoe is and how to distinguish mistletoes from other hemiparasitic plants, from epiphytes and from tumour-like plant growths caused by mites, wasps and other insects. Also discussed are the parasitic habit of mistletoes, their world distribution, their origins and relationships, the diversity and distribution of Australian mistletoes and the mistletoe lifecycle.

Diagnostic features used to identify mistletoes are identified in Chapter 2 along with some potential pitfalls for this pursuit. The chapter includes several sidebars: e.g. Box Mistletoe or Drooping Mistletoe?; Jointed mistletoes; How you can contribute. It is followed by species accounts, each presented on two facing pages. The scientific name and accepted common name, as well as 'Other names' are provided for each species. There are sections on the species' distribution, description, habitat, main hosts and associates (such as insect or other plant associates), as well as relevant 'Notes'. Also included are a species map, a print of a detailed watercolour by artist Robyn Hulley and a photograph to show mistletoe habit. Accounts for all

47 species found in Victoria, New South Wales and the southern half of Western Australia are provided.

Mistletoe ecology is examined in Chapter 4. Interactions with the host, host identity and range are investigated as are pollination, seed dispersal, flowering and fruiting seasons, and resemblance to hosts. Of particular interest to me were the sections dealing with the importance of mistletoes to the ecology of an area. Many believe mistletoes are harmful to their hosts but generally, where this is the case, harm is secondary in nature; e.g. the impact of drought conditions on the host may be exacerbated due to water lost to the mistletoe whereas, under normal rainfall conditions, the host would not suffer from the mistletoe. Many birds choose to eat the fruit of mistletoe in particular, although the nectar and even the whole flower may be consumed. Two birds, Painted Honeyeater and Mistletoebird, are considered specialists. These birds are believed to contribute largely to increasing the density of mistletoes in an area while non-specialist birds that often feed on mistletoe fruit are considered to spread the plant to new areas. Common Brushtail Possum, Bobuck and Greater Glider preferentially feed on mistletoe leaves rather than those of the host, but the reason for this has not been established. Mistletoes also are known to support a distinct assemblage of insects, many of which do not occur elsewhere, and are an important food resource for insectivores.

Mistletoe clumps also provide shelter for a variety of mammals, tree frogs and many birds: some 245 bird species nest in mistletoe clumps. Mistletoe plants shed leaves more frequently and are significant contributors to quantity and quality of leaf litter as they do not withdraw leaf nutrients prior to leaf drop. Thus mistletoes act as an ecological keystone, affecting both animal and plant biodiversity, and, presumably, other groups of organisms, although this is not discussed.

A discussion on European mistletoe culture, first impressions of Australian mistletoes by Europeans, Indigenous uses of mistletoes, Indigenous beliefs surrounding mistletoe, mistletoe in Australian art and mistletoe in popular culture is presented in Chapter 5. This is an interesting chapter, which I am sure the reader will enjoy, but I would have preferred Chapter 6, about restoration and management, to follow Chapter 4 as it seems a better fit.

The final chapter presents a good account of when and why mistletoe was viewed as harmful as well as some interesting examples of earlier control methods. Work gangs from Melbourne were conscripted to remove mistletoe from trees during the Great Depression, military flamethrowers were trialled on heavily infected trees and mistletoe-lopping days were organised by primary schools. Also discussed in this chapter are: Why has mistletoe increased?; Mistletoe control; Larger-scale management; and Mistletoe as an indicator of ecosystem health. This is followed by a section on Mistletoe restoration where an interesting project underway in central Melbourne is described: exotic plane trees, which are common street trees, are being rendered more useful for native animals through inoculation with creeping mistletoe. The final section deals with the highly relevant theme of climate change.

This is an excellent book and I have no hesitation in recommending it to readers.

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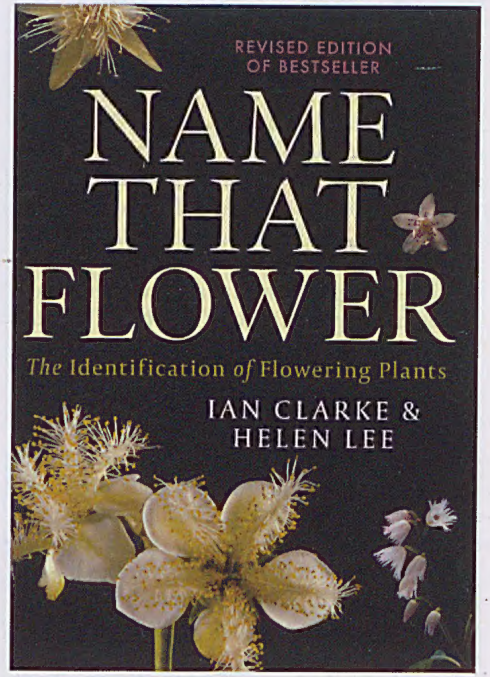
Name that Flower: The Identification of Flowering Plants

by Ian Clarke and Helen Lee

Publisher: *Melbourne University Press, Carlton, Victoria; 2019. 3rd edition. 438 pages, paperback, colour photographs, line drawings. ISBN 9780522876048. RRP $39.99.*



As with the previous two editions, the third edition of *Name that Flower: The Identification of Flowering Plants* is excellent. There are many textual changes reflecting better understanding of plant relationships because of advances in DNA analysis. This is demonstrated in the 46 descriptions of plant families provided in the book, most of which are accompanied by clear and detailed drawings. Photo imagery is magnificent with the number of plates nearly tripled. A key to plant species is included, allowing readers new to plant identification to learn this skill through a user-friendly approach that includes an expanded glossary. I now consider my edition 2 largely superfluous and highly recommend edition 3. It is well worth the recommended retail price (RRP) of $39.99 and swiftly brings you up to date with classificatory changes for a wide range of families. If you prefer your books online, an ebook is available: ISBN 9780522876055 at a RRP of $17.99.

There are eight chapters, with the bulk of the book providing the descriptions of plant families. These are followed by: References and Websites; Abbreviations and Contractions; Glossary; and Index.

Chapter 1, Getting Started, begins by providing the reader with a brief account of the evolution of plants. The earliest evidence for land plants comes from about 460 million years ago (Ma), with flowering plants becoming ecologically dominant 100 Ma. Humans are but a blip in time compared to plants. Early humans appeared only about 2.1 million years ago and modern humans *Homo sapiens* a mere 300 000 years ago. Then, as now, people needed to identify which plants were edible, medicinal, useful as tools, for building, for clothing or other uses. Thus the chapter progresses to a brief introduction to systematics and taxonomy. The importance of the scientific name is explained and, hopefully, this knowledge will encourage the reader to use this rather than a common name that may suggest a close relationship where one does not exist and may be given to more than one plant. One plant also may be given more than one common name. When teaching, I provided the following examples to demonstrate these points: Swamp Gum in Victoria is *Eucalyptus ovata* but in Tasmania it is *E. regnans*; *Eucalyptus regnans* in Victoria is called Mountain Ash but in Scotland *Sorbus aucuparia* also is known as Mountain Ash; *Eucalyptus* is in the family Myrtaceae while *Sorbus* is in the Rosaceae. The common name suggests they are more closely related. Perhaps I am focusing too much on this point, but I also recommend, very strongly, the use of scientific names. Chapter 1 also provides essential information needed to [illegible] the book.

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Chapters 2 and 3 respectively detail the structure of flowers and the arrangement of flowers on the plant in an easy to follow manner, complementing text with the use of superb diagrams. If you think a flower is a simple thing, you won't after reading this. Instead, I trust you will appreciate the variety of flowers that occur, e.g. does your flower have a gynoecium? If so, is it apocarpous or syncarpous? Is your flower hypogynous, perigynous or epigynous? What type of inflorescence do you have? Is it a corymbose panicle, a compound mochasium, or is it something completely different? The novice may be put off by such terminology, but *Name that Flower* presents this information in such a way that the reader will see the language of botany is not so frightening, e.g. 'The relative position of floral parts is one of the most important clues to the interpretation of floral structure' (p. 23).

Chapter 4 explains reproduction in flowering plants, focusing on sexual reproduction. This is divided into five sections: Pollination, Fertilisation, Development of the seed, Development of the fruit, and Germination. An introduction to plant structure and function is provided in Chapter 5 and is divided into six sections: Cells; Stems; Leaves (did you know they could be obtuse? For tips of leaves this must be important as it is illustrated twice!); Roots; The vascular system; and Plant growth. A lot of information is packed into these chapters and one should take the time to read and digest it. Doing so will ensure the novice can progress to the use of scientific keys with optimism rather than fear. Too often people will pick up a key to 'find the name' of a plant and be permanently put off using them because they haven't taken the time to understand plant basics or understand that accuracy requires terminology. These chapters are 'user-friendly' and easily lead to the ability to key out plants.

Chapter 6, Classification and Nomenclature — grouping and naming, provides a very useful introduction to these topics. The most recent classification of the Angiosperm (flowering plants) Phylogeny Group (APG) is presented. The classification incorporates a large amount of data, including numerous molecular studies, and has been well received by the botanical community. If you have wondered about the meaning of abbreviations after a scientific name, this is the chapter for you. These abbreviations identify who named the plant and provide a taxonomic history, e.g. The citation *Acacia suaveolens* (Sm.) Willd. tells us that this species once had another name given to it by JE Smith (abbreviated to Sm. as he was well renowned) and that the person who changed it was CL Willdenow (also well renowned hence Willd.). This knowledge gives us the stepping stone to discover information about this plant that was published under the earlier name. Other snippets of information also can be discovered through these abbreviations following plant names.

Chapter 7, The Process of Identification, leads us to the Holy Grail of using a key. It explains what equipment is needed, how to choose the specimen to examine, how to go about interpreting what is seen, how to cut a section and how to use keys. The final section of this chapter is the sample bracketed key to species illustrated in the book. I have tested it out on a few species and it appears to work well.

Chapter 8, the final chapter, provides the accounts of the plant families and forms the major component of the book (about 200 pages). The sequence of families closely follows the new classification scheme proposed by the APG in 2016. Brief notes are provided for each family as is an indication of size; also, for most families, the characteristic floral structure is provided, allowing easy comparison between families. Plant family spotting characteristics are provided where possible.

I cannot recommend this book highly enough.

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